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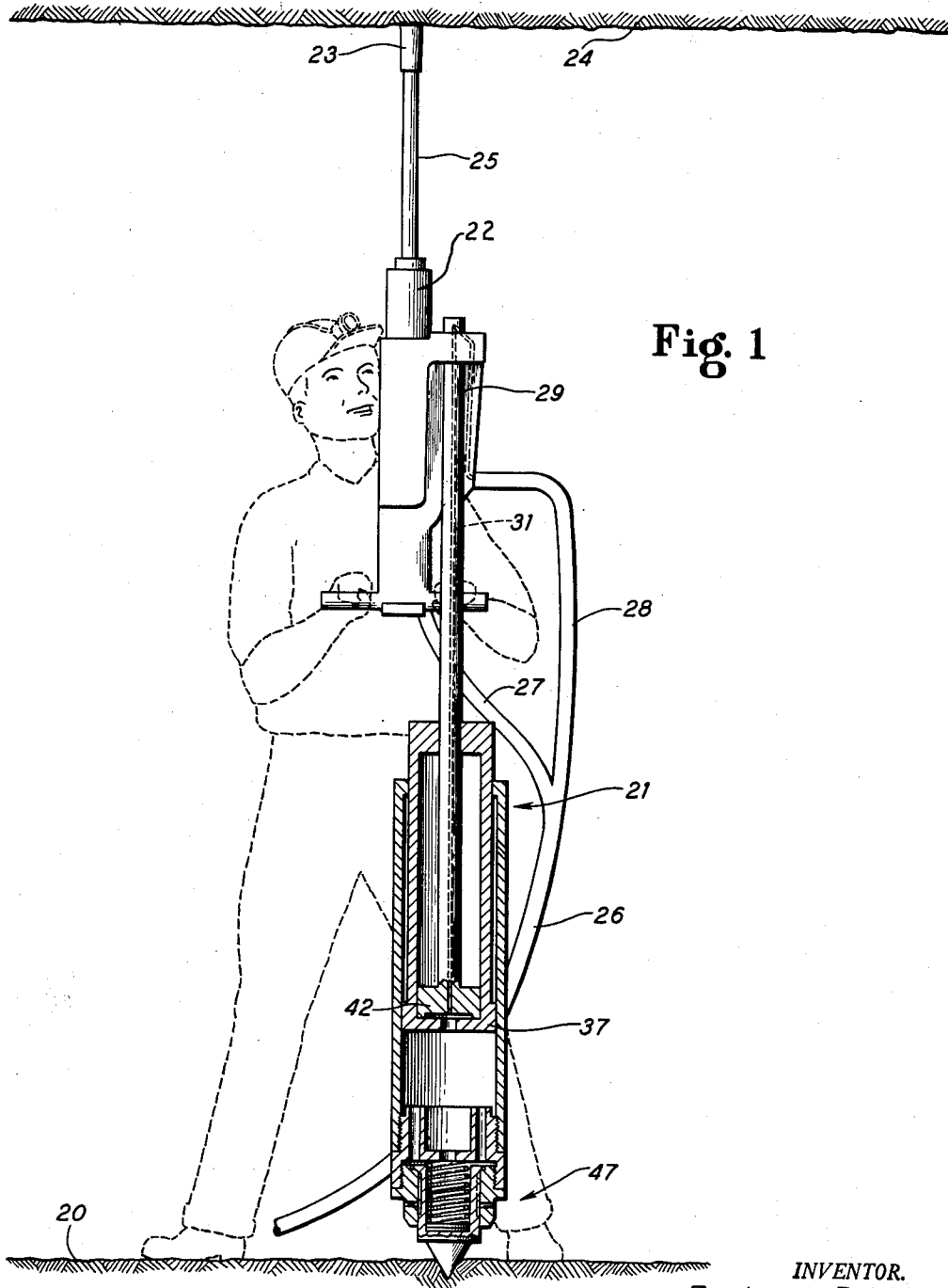
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2,754,804

AUTOMATIC FEED PRESSURE CONTROL FOR TELESCOPIC STOPPER LEG

Filed Jan. 15, 1954

3 Sheets-Sheet 1



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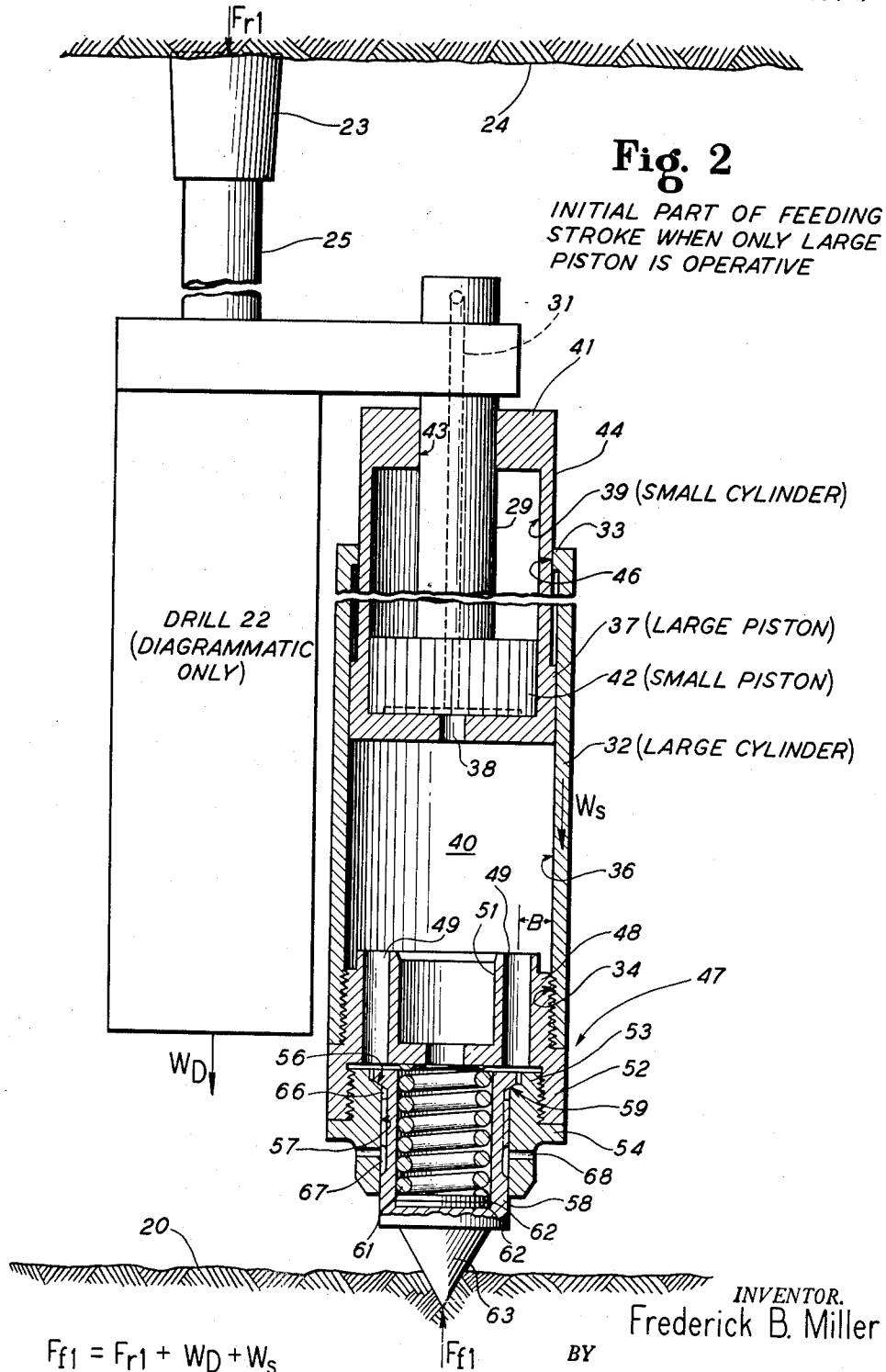
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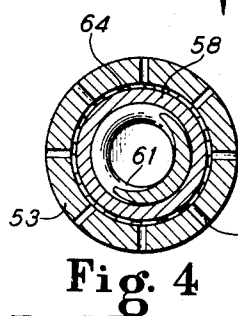
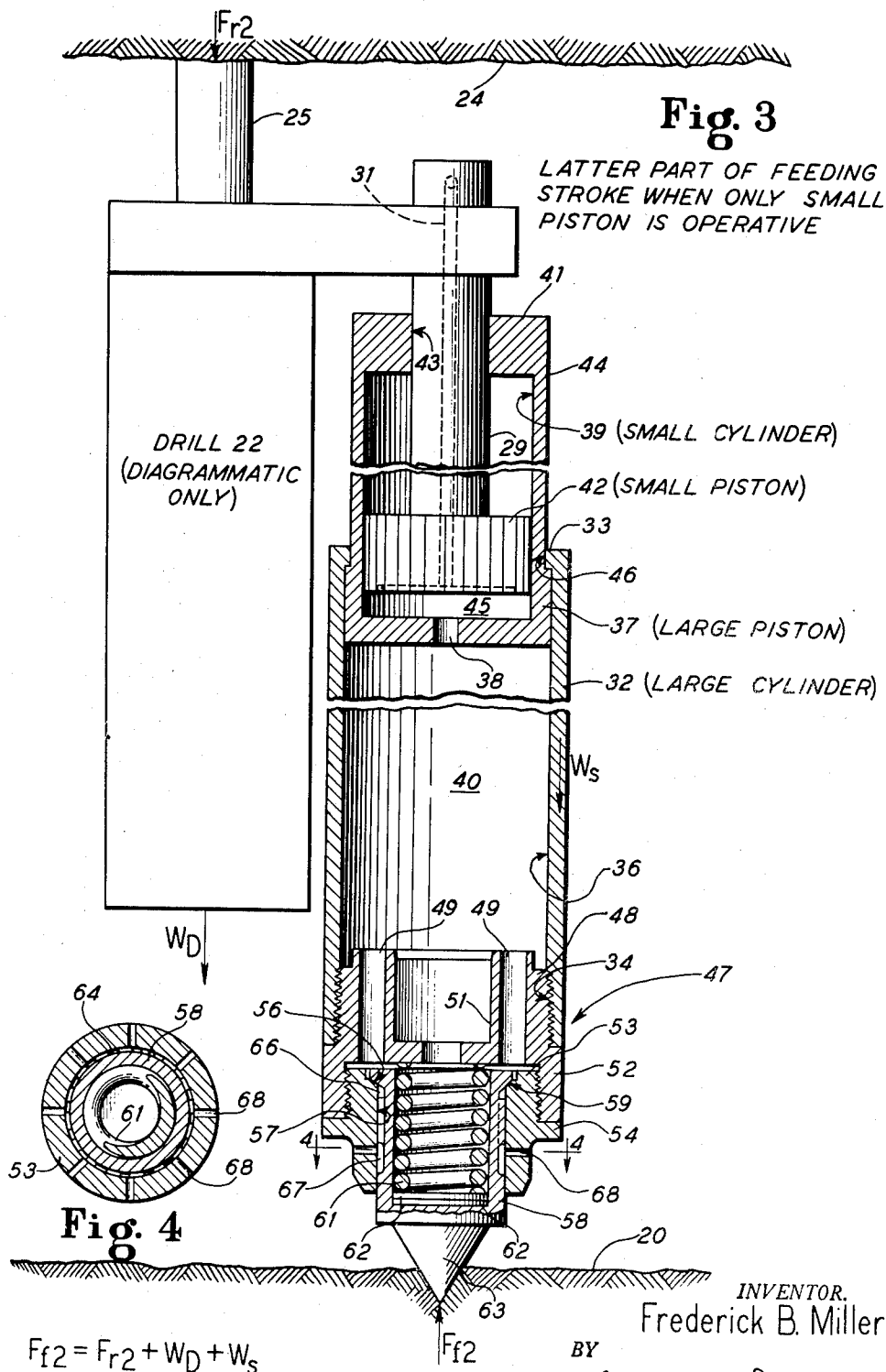
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AUTOMATIC FEED PRESSURE CONTROL FOR TELESCOPIC STOPER LEG

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This invention relates to drills and more particularly to an improved telescopic stoper leg for use in underground mining operations such as roof pinning work and the like.

Roof bolts are being used extensively in the United States to replace roof timbers in underground mining. In the usual roof pinning operation, approximately 1½ inch diameter holes will be drilled in the rock of the mine roof, from 1½ to 6 feet in depth, and spaced from 3 to 6 feet apart. These holes are drilled, for the most part, by a pneumatic, impact-type drill fed upward into the roof by means of a unit called a "stoper leg" which is simply a cylinder-piston arrangement which may be fed by the same compressed air supply that feeds the drill. A standard stoper leg is simply a piston within a cylinder, one connected to the drill and the other footed or abutted somehow against the floor. A telescopic stoper leg will have the standard arrangement, for example a piston carrying the drill on the end of a piston rod, the piston working inside a cylinder; in addition to this standard arrangement, the telescopic leg will have a separate, larger cylinder within which the first cylinder moves up and down in the manner of a piston.

The telescopic stoper leg, while somewhat more complicated, is preferable to the standard leg because of its ability to extend a greater amount. This is a substantial advantage underground, where head room is often quite limited, in that it permits a hole to be drilled with fewer drill steel changes.

A pneumatic impact type drill of the kind used in roof pinning may be considered simply a jack hammer with a drill bit on the end of it and with a built-in ratcheting arrangement for rotating the bit progressively between blows, on the return stroke. For the ratcheting mechanism to work properly, the feeding force exerted by the stoper leg must not be excessive, otherwise the bit will not rebound sufficiently from the end of the hole to permit the ratcheting mechanism to function. On the other hand, a substantial feeding force must be maintained to keep up the drilling rate. In other words, there is an optimum feeding force which should be exerted by the stoper leg on the drill. If the force is not high enough, drilling speed will be low; and if the force is too high, the rotation of the bit will be interfered with, again resulting in a low drilling rate.

Due to the manner in which a telescopic stoper leg operates, the feeding force varies, being a high value during the initial part of the feeding stroke when operating on the large cylinder, and being a relatively low value during the latter part of the stroke when operating on the small cylinder. Since only one of these forces can be the optimum, the other will result in a reduced drilling speed in the conventional telescopic stoper arrangement.

It is an object of the present invention to so modify the conventional telescopic stoper leg that it will produce the same feeding force when operating on both the large and small pistons.

Referring now, again, to the conventional telescopic

stoper, here is a typical example: a small piston and cylinder having 2½/16 inch diameter (4.2 sq. in. area) working inside a larger piston and cylinder having 2¾ inch diameter (5.94 sq. in. area). Assume that the drill, together with the small piston and piston rod, weighs 60 lb. and assume that in a particular mine roof a 318 lb. feeding force has been found to give the fastest feeding rate. To supply this feeding force to the bit, and carry the weight of the drill, a total feeding force of 378 lb. must be supplied by the stoper leg. 90 p. s. i. compressed air, against the small piston would supply that feeding force.

Suppose, therefore, that the stoper described above be used with a 90 p. s. i. compressed air supply. The larger piston, having 5.94 square inches area, would be operable during the initial part of the feeding stroke and would supply a total 535 lb. lifting force to the drill. Deducting the 60 lb. drill weight, this leaves a total of 475 lb. force pressing the bit into the roof. This is 50% higher than the optimum 318 lb. desired and is sufficient, by actual test observations, to prevent the bit from rebounding and from rotatably indexing properly between blows. This causes the feeding rate to be slower than it should be and the ratcheting mechanism will be overloaded. After the stoper comes to the end of the initial feeding stroke, and the large piston comes to a stop, the small piston will then be operative, supplying the optimum 318 lb. feeding force to the bit.

The conventional telescopic stoper leg, thus, as described in the two preceding paragraphs, supplies approximately 50% too high a feeding pressure in the first half of the drilling stroke. As a practical matter, this 50% figure cannot be reduced to any appreciable extent because of the necessity of maintaining a certain thickness of wall between the small cylinder and large piston.

It is an object of the present invention to incorporate a force-responsive relief valve in the foot of the telescopic stoper leg, so that when the force on the foot begins to exceed a value corresponding to a predetermined optimum, then the valve opens to discharge air and relieve the pressure.

Other objects and advantages of the present invention will be seen in connection with the accompanying drawings in which:

Fig. 1 is a mine view showing an operator drilling a roof bolt hole, using an improved telescopic stoper leg in accordance with a preferred form of the present invention;

Fig. 2 is an enlarged view of the stoper leg shown in Fig. 1, except that it is somewhat foreshortened for convenient illustration and the drill is merely shown diagrammatically as a weighted object; and

Fig. 3 is a view similar to Fig. 2 except that Fig. 2 shows the initial part of the feeding stroke where the large piston is operative and Fig. 3 shows the latter part of the stroke where the small piston is operative.

Parts are referred to by like reference characters throughout the drawings.

Referring more particularly to the drawings, Fig. 1 shows a preferred form of the stoper leg, generally designated 21, supporting a drill 22 having a bit 23 on the end of a drill steel 25 which is fed into a mine roof 24 for drilling holes for roof bolts. The drill and stoper leg are supplied with compressed air through a common line 26 having a branch 27 leading to the drill and a branch 28 leading to the top end of a hollow piston rod 29 and thence downward to the interior of the stoper leg through a bore 31.

Now directing attention to the details of the stoper leg and its incorporated foot valve, as shown in Figs. 2 and 3, it includes a main cylindrical housing or body 32 having an intumed shoulder 33 at its upper end and

3

a lower, internal-threaded end portion 34. The member 32 comprises what will be referred to herein as the "large cylinder" and has a smoothly finished cylinder bore 36 within which is fitted a "large piston" member 37 having a central opening 38 in the head end.

The large piston 37 has a finished bore 39 therewithin, terminating in an upper, intumed shoulder 41 and serves the dual function of being, also, a "small cylinder" within which is slidably a "small piston" 42 on the end of hollow piston rod 29, above-mentioned. The rod 29 is guideably fitted within a bore 43 in shoulder 41; likewise, the upper "rod" portion 44 of large piston 37 is guideably fitted within bore 46 of shoulder 33.

At the bottom of the stoper leg is a force-responsive foot valve capable of relieving pressure from the cylinders whenever the force exerted thereby exceeds a predetermined maximum. The valve is indicated generally by the number 47 and includes a plug member 48 threadedly engaged with the cylinder 32 and having a number of longitudinal perforations 49, 49 and 51 for the free passage of air, and to lighten it. The lower, cylindrical skirt section 52 of the plug has threadedly engaged with it a valve seat member 53. The latter has a flange 54 regulating its assembled position by abutment with the end surface of the plug 52. The upper end of the member 53 is faced with a beveled valve seat 56. The seat member 53 is provided with a through-bore 57 within which is slidably fitted a cup-shaped valve disc 58. The latter is formed with a beveled sealing surface 59 which is normally pressed against the seat 56 by spring 61 which acts between the plug and disc members 48 and 58. Spacers 62, 62 regulate the load applied by the spring. The bottom of foot end of the disc 58 is pointed, as at 63, to facilitate engagement with the mine floor 20.

For proper functioning of the foot valve, there must be adequate porting on the exhaust side to permit relieved air to escape. There should be no restriction of flow at all on the exhaust side of the relief valve. In other words, the relief valve should be capable of exhausting the stoper leg faster than the inlet port fills it with pressure, otherwise the relief valve will not be consistent in its operation, nor as effective as it should be. Here, as shown in Figs. 2, 3 and 4, this is accomplished by fluting the outside of the valve disc, as at 64, providing a pair of circumferential grooves 66, 67 interconnecting the flutes, and a number of radial exit ports 68, 68, at the level of the groove 67, in the member 53. In addition, it may sometimes be necessary to limit the flow rate of incoming air by restricting the diameter of the air input bore 31.

Now, taking a specific, dimensioned example to illustrate the present invention, it will be demonstrated how the size of the spring 61 can be determined from the equation

$$(1) \quad S = \frac{p_2 a B}{A} + W_s$$

where

S =pounds force exerted by spring 61

p_2 =p. s. i. nominal air pressure available in line 28

a =sq. in. area small piston 42

A =sq. in. area large piston 37

B =sq. in. annular area indicated "B" in Fig. 2

W_s =pounds weight of stoper leg including large cylinder 32 and all parts of the foot valve connected to it.

The derivation of Equation 1 is as follows:

As a general proposition, treating the entire drill and stoper leg as a free body

$$(2) \quad F_r + W_D + F_s = F_f$$

where

F_r =pounds force between roof and bit

F_f =pounds force between floor and stoper leg

W_D =pounds weight of drill, piston rod and small piston

W_s =(defined above)

4

Applying the general proposition (2) to the specific case of feeding on the small piston as shown in Fig. 3

$$(3) \quad F_{r2} + W_D + W_s = F_{f2}$$

5 Applying the same proposition to feeding on the large piston as shown in Fig. 2,

$$(4) \quad F_{r1} + W_D + W_s = F_{f1}$$

10 Since it is the object of this invention to equalize the feed pressure on the roof when either the large or small cylinder is feeding,

$$(5) \quad F_{r1} = F_{r2}$$

Combining (3), (4) and (5),

$$15 \quad (6) \quad F_{f1} - W_D - W_s = F_{f2} - W_D - W_s$$

Simplifying, we find the foot thrust against the floor is the same in both cases

$$(7) \quad F_{f1} = F_{f2}$$

20 Now, we refer to Fig. 3 in developing the thrust F_{r2} against the roof in the latter part of the feeding stroke when only the small piston is operative. This is done by treating the drill, piston rod and small piston as a unitary free body and equating the up and down forces:

$$25 \quad (8) \quad p_2 a = W_D + F_{r2}$$

where

p_2 =p. s. i. working air pressure available in line 28

a =area small piston 42

Rewriting (8),

$$(9) \quad F_{r2} = p_2 a - W_D$$

This same force F_{r2} must be maintained when the large piston is operative. To determine what the air pressure p_1 should be under that condition, refer to Fig. 2 and consider the large piston, small piston, piston rod and drill a single unitary free body and equate the up and down forces:

$$40 \quad (10) \quad p_1 A = W_D + F_{r1}$$

(NOTE.—Weight of large piston is disregarded in these calculations.)

where A =area large piston 37.

45 Substituting (5) in (10),

$$(11) \quad p_1 A = W_D + F_{r2}$$

or,

$$50 \quad (12) \quad p_1 = \frac{W_D + F_{r2}}{A}$$

Or, substituting (8),

$$55 \quad (13) \quad p_1 = \frac{W_D + p_2 a - W_D}{A} = \frac{p_2 a}{A}$$

Having now established p_1 , which is the pressure on the large cylinder in Fig. 2 which will supply the same feed force F_{r2} as the small piston with pressure p_2 in Fig. 3, we must determine the spring size needed to cause the foot valve to open at pressures above p_1 when the large piston is operable. To do this, consider the outer cylinder sleeve 32 as a free body, just as the valve begins to be opened by a pressure in excess of p_1 . Equating the up and down forces, we have:

$$65 \quad (14) \quad p_1 B + W_s = S$$

where

B =annular area marked B, Fig. 2

S =spring load

70 Substituting (13)

$$(15) \quad S = \frac{p_2 a B}{A} + W_s$$

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Assuming that in the embodiment illustrated, the nominal air passage p_2 is 90 p. s. i.; small piston area a is 4.20 sq. in.; large piston area A is 5.94 sq. in.; and the stoper weight W_s is 20 pounds, the size of spring required would be

$$(16) \quad S = \frac{(90)(4.20)(3.36)}{5.94} + 20 = 235 \text{ lb.}$$

According to Equations 5 and 9 the thrust against the roof at all times is

$$(17) \quad F_{r1} = F_{r2} = (90)(4.20) - 60 = 318 \text{ lbs.}$$

By contrast, if the foot valve 47 were not employed, the full line pressure p_2 (in this case 90 p. s. i.) would be exerted against the large piston, causing the force exerted against the bit to be $(5.94)(90) - 60 = 485 \text{ lb.}$; 167 lb. or almost 53% too high.

The operation of the improved stoper leg will now be reviewed.

First, consider its operation without the foot valve 47. That is, assume the lower end of large cylinder 32 is completely sealed, with no way of relieving the pressure. Now, when, say, 90 p. s. i. air is admitted (by a control valve not shown) to the stoper through the piston rod bore 31, it will enter the expansible chambers 40 and 45 within the large and small cylinders respectively. The lifting force on the large piston is $90 \times 5.94 = 535 \text{ lb.}$ while that on the small piston is $90 \times 4.20 = 378 \text{ lb.}$; hence, the large piston will move up first, carrying the small piston with it. When the large piston reaches the end of its stroke, the small piston continues the lifting action. While the large piston is operative, the thrust against the roof is $535 - 60 = 475 \text{ lb.}$ When the small piston is operative, the thrust is $378 - 60 = 318 \text{ lb.}$ If the latter is the optimum thrust, then the thrust by the large piston is approximately 50% too high.

Now, consider operation of the same stoper, but with the foot valve 47 using a spring 61 selected to exert a compressive load of 235 lb. in accordance with Equation 16.

With air at 90 p. s. i. available at the top of piston rod bore 31, the pressure within the chamber 40 when the large piston is operative (see Fig. 2) will be relieved down to a value determined by Equation 13,

$$p_1 = \frac{p_2 a}{A} = \frac{(90)(4.2)}{5.94} = 63.6 \text{ p. s. i.}$$

This pressure, multiplied by the large piston area, gives 378 lb. thrust. Deducting the 60 lb. drill weight, this gives 318 lb. thrust at the roof.

When the large piston comes to the end of its travel, and the small piston is operative, as shown in Fig. 3, the pressure within chambers 40 and 45 rises to the assumed 90 p. s. i. line, pressure, giving 318 lb. thrust against the roof.

Thus, the foot valve 47 makes it possible to maintain the same optimum roof thrust when either piston is operative.

While one form in which the present invention may be embodied has been shown and described it will be understood that various modifications and variations thereof may be effected without departing from the spirit and scope of the invention as defined by the appended claims.

I claim:

1. In a stoper leg for supporting a drill comprising a first cylindrical bore, a first piston member within said bore, a second cylindrical bore within said first piston member, a second piston within said second bore, a piston rod connected to the second piston for carrying a drill externally thereof, port and conduit means for conducting fluid under pressure to the interiors of said bores, a force responsive valve means in communication with said bores effective when opened to relieve pressure therefrom, a ground-engageable foot movably mounted on said leg and spring means biasing said foot in one direc-

6

tion, said foot being connected with said valve means to open the latter responsive to a predetermined drilling feed force above that corresponding to the strength of said spring.

2. A stoper leg comprising a cylinder, a piston in the cylinder, means supplying pressure fluid to extend the piston and cylinder, means for supporting and venting the cylinder comprising a member engageable with a support, a valve element carried by said member, a cooperating valve element carried by said cylinder and means for urging the valve elements to a position to prevent the escape of pressure fluid.

3. In a stoper leg having relatively extensible portions, one adapted to support a roof drill and the other adapted to be footed against a support, said leg having at least one extensible chamber intermediate said extensible portions and means for conducting fluid under pressure into said chamber causing said leg to exert a feeding force on a drill corresponding to the pressure within said chamber, a feeding force responsive pressure regulating valve means connected with said chamber, and actuating means carried by said valve means and engageable with a support and operable in response to rise of said feeding force above a predetermined maximum for operating said valve means to limit the pressure in said chamber to a value corresponding to a predetermined maximum for said feeding force.

4. The structure defined in claim 3 together with closure means for urging the valve means to a position to prevent the escape of pressure fluid.

5. The structure defined in claim 4 wherein said actuating means is movable relative to said leg and said closure means comprises a spring and the predetermined maximum feeding force corresponds to and is determined by the strength of said spring.

6. The structure defined in claim 5 wherein said actuating means is ground engaging.

7. In a stoper leg having relatively extensible portions, one adapted to support a roof drill and the other adapted to be footed against a support, said leg having at least one expansible chamber intermediate said extensible portions and means for conducting fluid under pressure into said chamber causing said leg to exert a feeding force on a drill corresponding to the pressure within said chamber, a feeding force responsive pressure regulating means connected with said chamber, said regulating means including a support engaging member movably mounted on said leg and urged in one direction by the drill feeding force, a valve means connected with the member to effectively relieve the pressure in said chamber when the member is urged in said one direction to limit the feeding force exerted by the leg, and means urging said member in the opposite direction to effectively position the valve means to prevent the escape of pressure fluid.

8. A stoper leg comprising a cylinder, a piston in the cylinder, means supplying pressure fluid to extend the piston and cylinder, pressure relief means for supporting and venting the cylinder, said relief means including a member engageable with a support for actuating the relief means to vent the cylinder and a closure means normally urging the relief means to a position preventing the escape of pressure fluid.

9. In a stoper leg for positioning between relative relative resistant supports comprising a cylinder, a piston in the cylinder, means supplying pressure fluid to extend the piston and cylinder, a relief means in communication with said cylinder effective when in open position to relieve pressure therefrom, said relief means including a support engaging member for actuating the relief means to the open position and a closure means normally urging the relief means to a closed position.

10. In a stoper leg having relatively extensible portions, one adapted to support a roof drill and the other adapted to be footed against a floor, said leg having at

least one expansible chamber intermediate said extensible portions and means for conducting fluid under pressure into said chamber causing said leg to exert a feeding force on a drill corresponding to the pressure within said chamber, a feeding force responsive pressure relief valve connected with said chamber, said relief valve comprising an actuating member slidably journaled in said leg along the longitudinal axis thereof, spring means biasing said actuating member in a direction to urge said valve to closed position, said actuating member being connected with one of said extensible portions of said leg for movement in response to the drill feeding force in a direction opposite the spring bias to open said valve to relieve pressure from said chamber when the feeding force on the drill exceeds a maximum determined by the spring bias.

11. In an elongated stoper leg, means extending said leg by force in response to admission of fluid under pressure therinto, and a force responsive relief means limiting the maximum force applied thereto including a valve means regulating the pressure within said leg, said valve means including an actuating element engaging a support, said element being movable in response to a predetermined maximum force to actuate the valve means to an open position to limit the pressure in said leg to a value corresponding to said predetermined maximum force and a means normally urging the valve means to a position preventing the escape of fluid.

12. In a stoper leg having a drill supporting section and a footing section extensible relative to each other by self-contained piston and cylinder means, the latter including a first cylinder and piston, and a second cylinder and piston carried by the first piston, said first cylinder and said second piston being connected respectively to said extensible sections, means for conducting fluid under pressure into said cylinders, said footing section comprising a relief valve communicating with said cylinders, a spring urging said valve to closed position, and an extension on said valve extending beyond said leg and engageable with a support effective to unseat said valve to relieve pressure from said cylinders when the feeding force on a drill exceeds a maximum determined by said spring.

13. In an extensible telescopic stoper leg for supporting a drill comprising a first cylindrical bore and piston, a second cylindrical bore within said first piston and a second piston smaller in area than said first piston within said second bore, means for conducting fluid under pressure into said bores causing said leg to extend and exert a feeding force on a drill through successive movement of said pistons within their respective bores, a feeding force responsive pressure relief means carried by said leg in communication with said bores and effective when in an open position to relieve the pressure therein, said relief means including a member engageable with a support for actuating the relief means to said open position and a closure means for positioning said relief means in a closed position to prevent the escape of pressure fluid from said bores, said member being responsive to a predetermined maximum feeding force so that the feeding force exerted on said member by each piston of unequal area remains equal and constant by varying the pressure in the respective bores throughout the full period of the extension of the leg.

14. The structure defined in claim 13, wherein said member is movably mounted on said leg and said closure means comprises a spring normally biasing said member

to the closed position and the predetermined force corresponds to and is determined by the strength of said spring.

15. The structure defined in claim 14, wherein said member is ground engaging.

16. In an extensible telescopic stoper leg for supporting a drill comprising a first cylindrical bore and piston, a second cylindrical bore within said first piston and a second piston smaller in area than said first piston within said second bore, means for conducting fluid under pressure into said bores causing said leg to extend and exert a feeding force on a drill through successive movement of said pistons within their respective bores, a feeding force responsive pressure relief valve means in communication with said bores, said valve means including a member having an actuating portion engageable with a support, a valve element carried by said member, a cooperating valve element carried by one of said bores, said member being movably mounted on said leg for movement between a first position wherein the valve means is closed and a second position wherein the valve means is open, and closure means urging the member to the first position, said actuating portion of said member being responsive to a predetermined feeding force to urge said member from the first to the second position whenever said feeding force exceeds a predetermined maximum.

17. The structure defined in claim 16 wherein said closure means comprises a spring normally biasing said member to the first position and the maximum predetermined feeding force corresponds to and is determined by the strength of said spring.

18. The structure defined in claim 16 wherein said actuating portion of said member extends beyond the stoper leg and engages the ground.

19. An extensible force exerting mechanism for positioning between relative resistant surfaces, said mechanism including a chamber, means for extending the mechanism by force in response to admission of fluid under pressure into the chamber, pressure regulating means in communication with the chamber effective when in open position to relieve the pressure therein to limit the maximum value of the force to be exerted by the mechanism, closure means normally urging the regulating means to a closed position, an actuating member carried by the mechanism and engageable with a support, said member being connected to the regulating means to actuate same to the open position thereof to relieve the pressure in the chamber when the force exerted by the mechanism is greater than a predetermined maximum value.

20. The structure defined in claim 19 wherein said pressure regulating means includes cooperating valve elements, one of said valve elements being carried by said chamber and another of said valve elements being carried by said actuating member.

21. The structure defined in claim 20 wherein said actuating member is movably carried by said mechanism and said closure mechanism comprises a spring normally biasing said actuating member to close the valve elements and the predetermined maximum force corresponds to and is determined by the strength of said spring.

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